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HIPPELATES EYE GNATS: A REVIEW AND BIBLIOGRAPHY

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USAF SCHOOL OF AEROSPACE MEDICINE
Aerospace Medical Division (AFSC)
Brooks Air Force Base, Texas 78235



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This report has been reviewed and is approved for publication.

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HIPPELATES EYE GNATS: A REVIEW AND BIBLIOGRAPHY

INTRODUCTION

Hippelates are small flies, frequently called "eye gnats" because of their persistent habit of hovering about the eyes and feeding on lachrymal secretions. In areas of the United States where Hippelates are abundant, severe eye-gnat annoyance can cause reduction of outdoor work and recreational activities (105).

At the request of the Director of Base Medical Services, Robins AFB, Georgia, an investigative eye-gnat study was initiated by the Entomology Section, Epidemiology Division, USAF School of Aerospace Medicine. This request resulted from a history of severe eye-gnat annoyance at Robins AFB and no effective control techniques. The primary objective of the study, therefore, was to find a control measure that would reduce the eye-gnat annoyance problem to an acceptable level. A review of pertinent literature was the first step toward accomplishing this objective.

HIPPELATES PUSIO

Identification

Hippelates pusio is the dominant eye-gnat pest species in the Robins AFB area (167). These gnats are nonbiting Diptera in the family Chloropidae. Members of this family are characterized by a large frontal triangle, the sclerotized plate on which the ocelli are situated. Most Hippelates are very small (1.5 to 2.5 mm long). A distinct, curved, shiny black spine on the tibia distinguishes these adults from other Chloropidae (23). Several taxonomic references are available for speciating the adults of the genus Hippelates (11, 175, 177, 179). Immature stages of H. pusio can be identified with the aid of detailed drawings provided in papers by Herms and Burgess (21) and Hall (48).

Life Cycle

Most eye-gnat breeding occurs in light, moist, freshly disturbed soil with a 1%-27% content of organic matter (9, 21-24, 31, 34, 49). Adequate soil moisture appears to be one of the most important requirements of an oviposition site because H. pusio eggs desiccate rapidly when deposited on a dry medium. Hall (48) found that newly hatched H. pusio larvae immediately tunnel downward to feed and develop in moist areas of the soil and that pupation generally takes place in the interface region between moist and dry areas of the soil.

Duration of the H. pusio life cycle varies primarily with the amount of available food and moisture and the temperature of the soil. Under optimum laboratory conditions, the developmental period for each H. pusio stage is 2 days for eggs, 8-10 days for larvae, 7-9 days for pupae, and 4-6 days for adult maturation and oviposition (42). Although developing from egg to adult may take as little as 17 days in the laboratory, 28 days to 6 months may be required for one generation to develop in the field (9). Overwintering of H. pusio in the larval stage accounts for most of the longer developmental times. In the Robins AFB area, H. pusio adult populations annually peak from July through September (16).

Behavior

Eye gnats frequently come to the eyes, ears, nose, mouth, and wounds or sores of man and animals to feed on mucous and sebaceous secretions, pus, and blood (23, 29). They are extremely persistent pests. When searching for a feeding site they crawl over the skin or intermittently fly and alight on the skin, which adds to the annoyance of the host (23). After being brushed away, the gnats immediately and repeatedly return to feed.

According to studies made by Gerhardt and Axtell (61), the physical environmental threshold values that must exist before H. pusio is attracted to man are: temperatures above 17°C (62°F), vapor pressure deficit of 0.25 mm Hg or greater, light above 5.38 milliphots (5 ft-c), and wind below 4 km/hr (2.5 mi/hr). At temperatures above 34°C (93°F), flight activity of H. pusio decreases (62). During the high temperatures of midday, the activity is primarily in shaded areas; and in early morning and late evening, activity occurs more frequently in warmer sunny areas (62).

Flight Range

Eye gnats will fly with air moving at velocities up to 9.3 km/hr (6 mi/hr), and they are capable of flying against the wind at wind speeds of 3.1 km/hr (2 mi/hr) or less (60). In Georgia, Dow (1) reported catching 15 H. pusio gnats in less than 3.5 hours in traps located more than a mile (1.6 km) from the release box. Mulla and March (2) observed a flight range for H. collusor in California of up to 4.3 miles (6.9 km) downwind.

Importance

In localities where Hippelates eye gnats attain high population levels, these pests are considered to be a major public health problem (29). Their attraction to eyes, ears, nose, mouth, wounds, and sores of man make them a constant source of annoyance. After conducting extensive studies of this pest, Mulla (105) stated, "There is no doubt that Hippelates eye gnats are a deterrent to public welfare, hindrance to recreational pursuits, and are a cause of physical and mental discomfort...Eye gnats, in general,

and in California in particular, are important not because of their potential role as disease vectors, but they are dreaded on account of their persistent attacks causing constant annoyance."

Although Hippelates are nonbiting, they possess mouthparts with minute spines capable of scarifying epithelial linings, and thus pathogenic organisms carried by the eye gnats can gain a foothold (151). Circumstantial evidence incriminates Hippelates gnats as vectors of conjunctivitis in the United States and other countries (146, 149-153, 159). In Jamaica, isolations of the yaws organism, Treponema pertenue, have been made from Hippelates, and this organism has been experimentally transmitted to rabbits by Hippelates (154-157). Blanco et al. (147) and Parra and Blanco (158) reported the transmission of mal del pinto organisms by Hippelates to human volunteers in Mexico. Eye gnats have been shown to transmit Naga sore in Assam (163). Hippelates probably contributed to the rapid spread of an outbreak of Streptococcus pyogenes skin infection in Trinidad (146). In addition to vectoring human disease, Hippelates have been proven experimentally to be vectors of bovine mastitis and incriminated as potential vectors of anaplasmosis in cattle in the United States (160-162, 164, 165).

HIPPELATES CONTROL

Attractants/Repellents

Of the numerous attractancy studies conducted with eye gnats, only Dow (68) and Snoddy (83) have worked extensively with H. pusio. Using a rotary bait station, Dow found that aged liver bait was more attractive to H. pusio than egg bait. In his studies of the attractancy of various milk components, Snoddy reported that the most promising carbonyl compound, 2,3-pentanedione, was not attractive to H. pusio. Most of the published eye-gnat studies have been accomplished with H. collusor, and have been performed by Hwang (69-73) and Mulla (74-82) and their associates. None of the work, however, has resulted in an effective or practical bait which can be mixed with a toxicant or chemosterilant for Hippelates control.

Mulla (74) tested 15 chemicals for their repellency activity against H. collusor and found that dimethyl carbate, ethyl hexanediol, and Triple Mix Repellent (64% dimethyl phthalate, 17% ethyl hexanediol, and 19% Indalone) performed best. His results also showed that a standard military-issue repellent, diethyltoluamide (deet), provided excellent protection for 30 minutes after application and good protection from 30 to 120 minutes. In a repellency screening test with 20 chemicals against H. pusio, Axtell (66) found that the most effective repellents were Triple Mix, MGK (McLaughlin Gormley King Co.) Formula 5780, MGK Repellent 11, butyl acetanilide, and butyl ethyl propanediol. He found only moderate repellency by deet against H. pusio. Further studies are needed, however, to develop a highly effective and acceptable repellent that will offer good protection against Hippelates eye-gnat annoyance.

Biological/Cultural Control

Biological control work with eye gnats has primarily involved collecting and identifying parasites found in Hippelates larvae and pupae. So far, very little work has been done with rearing and releasing parasites or predators to control Hippelates.

Two parasites taken from H. pusio are a flagellate, Herpetomonus muscarum, and an egg parasite, Ooencyrtus submetallus Howard (85, 86), most often found in eggs of the southern green stink bug. Three hymenopterous parasites of H. collusor have been successfully cultured in the laboratory: Phaenopria occidentalis Fouts, Spalangia drosophilae Ashmond, and Eupteromalus nidulans Thomson (89). Of the three, only S. drosophilae shows any promise in field release studies. In one test where Legner and Bay (93) exposed Hippelates eye gnats to natural field parasitism, only Trybliographa spp. and S. drosophilae parasites were recovered. Besides Hymenoptera, beetles of the subfamily Aleocharinae, belonging to a tribe of which very little is known, have been found parasitizing Hippelates in Coachella Valley, California (103).

Legner et al. (102) and Mulla (105, 143) have tested the effects of varying farming techniques on H. collusor populations. In Legner's study, naturally breeding field populations of H. collusor were reduced when urea fertilizer was applied to the soil. Control apparently was due in part to an increase in the abundance of Saprolegnia (fungi pathogenic to gnat larvae) in some soil cultures treated with urea. Mulla (105) reported that flexible cultural control would help control eye gnats. The measures he found detrimental to eye-gnat production in the soil were: (1) using recommended herbicides to control weeds in tree fruit crops, (2) using frequent tillage to control weeds before growth reached 2-3 in. (5-7.3 cm), and (3) not incorporating vegetative matter into the soil during the heavy breeding season of Hippelates eye gnats.

Chemical Control of Adults

Axtell and Edwards (107) tested the effectiveness of nine insecticides applied as thermal fogs to kill caged laboratory-reared H. pusio adults. They found that naled and propoxur were the most toxic. Mulla (111) observed that of the 15 (primarily experimental) insecticides he evaluated against H. pusio and H. collusor, malathion had the lowest toxicity. Other adult Hippelates chemical control studies have used a variety of ground and aerial control techniques, but none reported in the literature have yielded a practical and effective method of controlling Hippelates adults (108-110, 112, 114).

Chemical Control of Larvae

Excellent control of H. pusio has been obtained for short periods in Brooks County, Georgia, using soil applications of aldrin and chlordane

(114). The Environmental Protection Agency restrictions on many of the residual insecticides and the lack of long-term benefits, however, make chemical control of Hippelates larvae impractical. Additionally, in California where soil treatments with residual insecticides have been used, eye-gnat populations developed resistance to the insecticides (115).

Chemosterilants

The use of chemosterilants has been difficult to implement as a control measure due to both the limited effectiveness of the chemicals tested and the difficulty of exposing large numbers of eye gnats to the compounds (131-134).

Traps and Other Potential Control Methods

Attempts to use traps to control eye gnats have been unsuccessful (135, 136). The primary emphasis on Hippelates trap studies has been with their development for eye-gnat surveillance (137-139). The only other potential control method of note is the use of radiation to sterilize Hippelates. Flint (140) studied the effects of gamma radiation on the fertility and longevity of H. pusio. He was able to sterilize both sexes by treating the late pupal stages with a dose of 4,500 R. The males, however, recovered some fertility 3 weeks after radiation, and the 4,500-R dose level did not increase eye-gnat mortality. Although Flint's study indicated that radiation sterilization shows potential as an eye-gnat control technique, no additional tests with eye-gnat radiation have been reported.

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The author concludes that

CONCLUSIONS

The primary emphasis in developing an eye-gnat control program at Robins AFB, Georgia, should be placed on controlling the adults. Currently, the control of immature stages would be impractical because of the Federal restrictions placed on the use of residual insecticides and the expense of treating large eye-gnat breeding areas. Of the adult control procedures available, insecticide treatments similar to those used for mosquito control would be the most promising approach because of the Air Force's inability to treat off-base areas, and the time and expense required to develop a control program using any of the other available control techniques.

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